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(71) Applicants
Honda Giken Kogyo Kabushiki Kaisha (Japan),
8-go 27-ban Jingumae 6-chome, Shibuya-ku, Tokyo, Japan.
Kabushiki Kaisha Keihinseiki Seisakusho (Japan),
386-banchi Ichinotsubo Nakahara-ku, Kawasaki-shi, Kanagawa-ken, Japan

(72) Inventors
Isamu Sasao
Yoshiyasu Takaoka

(74) Agent and/or Address for Service
Haseltine Lake & Co,
Hazlitt House, 28 Southampton Buildings, Chancery Lane, London WC2A 1AT

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None

(58) Field of search
B3A

(54) Manufacturing valve seat-forming member

(57) The valve seat-forming member (8) of a fuel injection valve has a bore (9) formed to serve as a guide for opening and closing displacement movements of a valve rod, a valve seat (10) continuing from the guide bore formed for seating of a valve body and a fuel discharge port (11) continuing from the valve seat formed. The guide bore and valve seat are burnished and then the seat-forming member is hardened. The burnishing is effected by a tool (17) while the seat-forming member remains in the same jig in which a different tool formed the bore and seat.

FIG.4

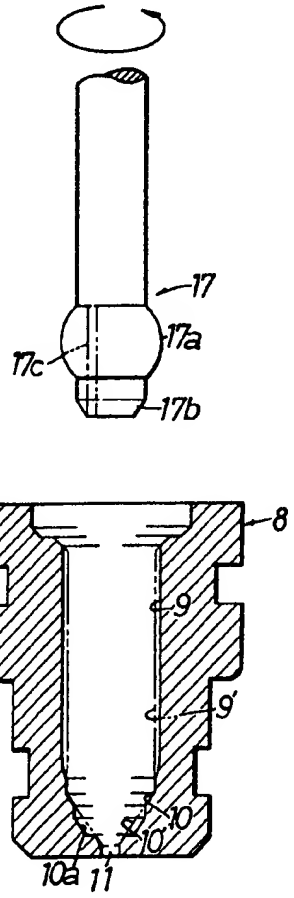

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FIG.1

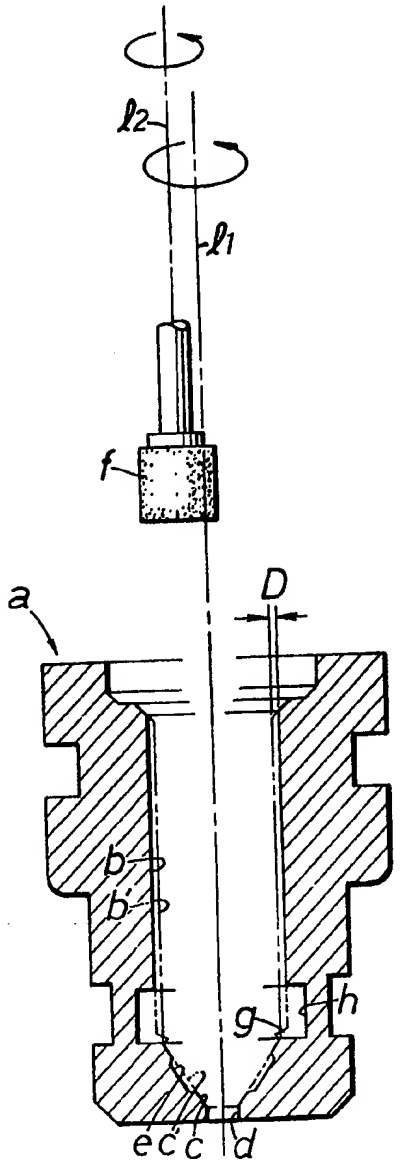

FIG.2

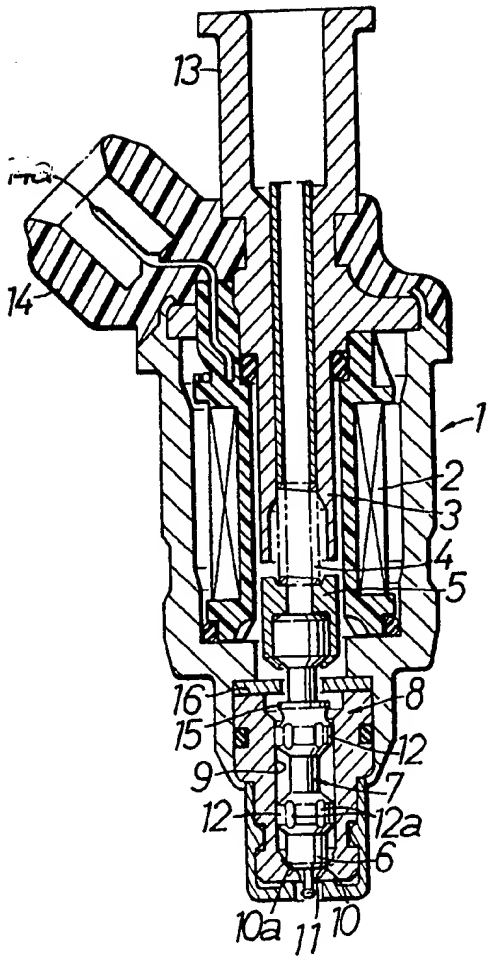

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FIG.4

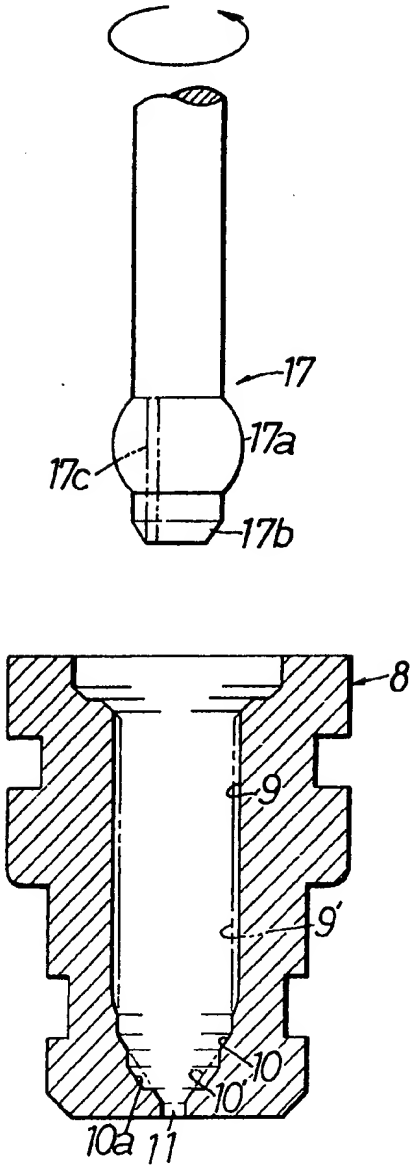
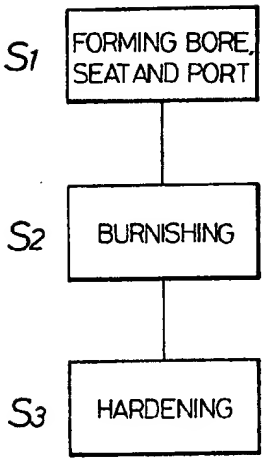


FIG.3



SPECIFICATION

A method of manufa turing of a valve seat-forming memb r of a fuel inj ction valve

This invention relates to a method of manufacture of a valve seat-forming member of a fuel injection valve of the type including a main fuel injection valve body, a movable core attracted magnetically to a fixed core by an electromagnetic coil placed within the main fuel injection valve body, a valve rod whose end is provided with a valve body and which is attached to the movable core, and a valve seat-forming member attached to the end of the main fuel injection valve body so that the valve rod can be inserted into it.

Referring to Fig. 1 which shows a construction known in the art, therein it is seen that the valve seat-forming member of a fuel injection valve of the described type includes a guide bore b for the guiding of opening and closing displacement movements of the valve rod, a valve seat c formed at the end of the guide bore b in continuation from the guide bore, and a fuel discharge port d in continuation from the valve seat c. In this construction, it is the customary practice to polish a bore b' bored in a blank of a valve seat-forming member *a*, and to polish a bore c' in the valve seat c in order to form the guide bore b and a seat surface e of the valve seat c. In greater detail, the bore b' is polished by a grinding tool f that is moved around an axis of rotation l_1 aligned with the axis of the guide bore b, while rotating the tool about its own axis of rotation l_2 which is parallel to the axis of rotation l_1. The seat surface e of the valve seat c is polished by a grinding tool which has a different shape from that of the grinding tool f.

This method produces the following problems:

1. When polishing, the surface being polished must be made rigid, as is well known in the art, so that hardening is effected before the polishing; that is, between the step of forming the starting bore and the polishing step. Therefore, the blank of the valve seat-forming member *a* is temporarily removed from the jig after the formation of the starting bore, the blank is then subjected to hardening, and it is thereafter refitted into the jig for the polishing operation. Thus, the fitting and removal of the blank into and from the jig are time-consuming operations.

2. In connection with the problem described in (1), when a blank is repeatedly fitted into and removed from the jig, the concentricity between the axis of rotation of the tool used for forming the starting bore (e.g., a drill) and the axis of rotation (corresponding to l_1) of the grinding tool is disturbed, so that often the bore b' and the seat surface e are not uniformly polished over their entire surfaces.

3. In a polishing operation, a relatively larg thickness or margin D must be provid d. If an error, even slight, occurs in the positioning of the grinding tool f because of a displacement of the axis of rotation l_2 with respect to the axis of rotation l_1, for example, the bore b can not be uniformly polished.

4. Since the tip of the grinding tool f is easily worn, a sharp flashing or edge g can be formed at the end of the polished guide bore b where it is joined to the seat c. The width of the flashing g corresponds to the depth of the polishing margin D. In order to prevent the formation of flashing or edge g, an undercut escape groove h must be formed in advance by cutting into the bore b'; however, this is difficult to do.

5. The escape groove h forms, in turn, a fuel trap within the valve seat-forming member *a* causing a drop in the fuel velocity which has an adverse influence on the fuel injection.

6. In connection with problem (4) above, if the swarf produced when cutting the escape groove h remains, it can choke the fuel discharge port d or cause fuel leakage. To remove the swarf, thorough cleaning must effected, but it is extremely difficult to completely remove the swarf. This leads to marked variations in the fuel injection quantity and performance.

An object of the invention is to provide a method for forming a guide bore and valve seat in a fuel valve which eliminates the above noted problems.

This object is achieved by a method which employs burnishing instead of the surface finish provided by polishing, and includes, in sequence, forming a hollow interior in the valve seat-forming member, burnishing the hollow interior to its finished size and hardening the material at the surface of the hollow interior.

The method of the present invention improves workability and produces a high-precision fuel injection valve suitable for an electronic fuel injection device.

In further accordance with the method of the invention, the hollow interior is constituted by a starting bore serving as a guide for opening and closing displacement movements of the valve rod and a valve seat continuing from the guide bore and leading to a fuel discharge port. The burnishing is effected on at least one of the guide bore and valve seat and, preferably, the bore and seat are burnished concurrently.

The guide bore, seat and port are preferably formed by a drill which is rotated around a given axis and a seat-forming member is held in a jig during the drilling operation and during the following burnishing operation in which the bore and seat are burnished to their final size. In this way, th seat-forming member need not be removed from the jig and can

remain in place both for the initial drilling operation and the subsequent burnishing operation.

For a better understanding of the invention and to show how the same may be carried into effect, reference will now be made, by way of example, to Figures 2 to 4 of the accompanying drawings, in which Figures:

Figure 2 is a sectional side view of a fuel injection valve using a valve seat-forming member obtained in accordance with the present method,

Figure 3 is a flow chart of the manufacturing sequence of the present method, and

Figure 4 is a sectional side view of the valve seat-forming member, illustrating a burnishing step of the present method.

Referring to Figure 2, therein is seen a main injection valve body 1 and an electromagnetic coil 2 disposed within the main valve body 1.

A fixed core 3 is provided within the electromagnetic coil 2, and a movable core 5 is also provided within the coil 2, in a forward portion thereof in the axial direction. A spring 4 acts on the movable core 5 to urge the core 5 away from fixed core 3. A valve rod 7 having an end with a valve body 6 is connected to the rear end of the movable core 5 and the valve rod 7 extends into a valve seat-forming member 8 attached to the end of the main valve body 1.

The valve seat-forming member 8 is provided with a guide bore 9 that extends in the axial direction, a valve seat 10 formed at the end of the guide bore 9 in continuation therefrom, and a fuel discharge port 11 in continuation from the valve seat 10. The valve rod 7 extends into the guide bore 9 such that a pair of increased diameter portions 12, which are provided with fuel passage grooves 12a along the outer peripheries thereof, can slide along the surface of the guide bore 9, whereby opening and closing displacement movements of the valve rod 7 are guided by the guide bore 9. The valve body 6 at the end of the valve rod 7 is normally pressed into contact with the seat surface 10a of the valve seat 10 by the spring 4. When electrical voltage is applied to the electromagnetic coil 2, the movable core 5 is magnetically attracted towards the fixed core 3 against the force of the spring 4, and the movement of the valve rod 7 in this instance releases the valve body 6 from the seat surface 10a, so that fuel from a socket portion 13 connected to a fuel conduit (not shown) is discharged from the fuel discharge port 11.

The interior of the seat-forming member 8 is formed by a method which includes the steps of boring the guide bore 9, the valve seat 10, and the fuel discharge port 11 into the blank, as shown by step S_1 in Fig. 3; burnishing the guide bore 9 and/or the valve seat 10 as shown by step S_2; and hardening th blank after the burnishing step as shown by step S_3; in accordance with the characterizing feature of the pr sent invention. It is the burnishing step before the hardening step that is particularly noteworthy as will be described hereafter.

The burnishing step is carried out by inserting a burnishing tool 17 into the starting bore 9′ while the tool is rotated relative to the blank, as illustrated in Fig. 4. Unlike the conventional polishing step, this method eliminates the necessity of cutting an undercut escape groove in the bore 9′, so that the bore 9′ is formed as a straight bore with no escape groove, and can be finished as it is to form the guide bore 9. By virtue of this method, the burnishing step can be carried out immediately after the bore 9′ is formed while the blank is still fixed in the same jig and thereby the concentricity of the tool 17 with the bore 9′ can easily be obtained whereby the producibility as well as the finishing accuracy can be improved.

The burnishing tool 17 is provided with a pair of first and second burnishing surfaces 17a and 17b which come into sliding contact with the bore 9′ and the valve seat 10′, respectively, and tool 17 is rotated relative to the blank on the same axis as that of the borer drill so that the second burnishing surface 17b burnishes the seat 10′ to form the seat surface 10a which is finished simultaneously with the guide bore 9, thereby improving the production method. In accordance with this method, since only one tool 17 is utilized, the concentricity can be improved, the uniformity in the surface finishes of the guide bore 9 and the seat surface 10a can also be improved, and thus the accuracy of the fuel injection valve can be improved. Lubricant grooves 17c are formed on the burnishing surfaces 17a and 17b, if necessary.

As described above, since the present invention employs burnishing of the guide bore and of the valve seat to provide the finish, the present invention eliminates the necessity of cutting an undercut, escape groove as required in the conventional polishing operation, and thereby simplifies the work while preventing any adverse effects which can result from the cutting swarf and the escape groove. Since the step of forming the bore and the burnishing step can be carried out in sequence, it is not necessary to repeatedly remove the blank from the jig and fit it back therein and the burnishing can be effected while the blank remains fixed in the jig used for the formation of the bore. Therefore, the production as well as the accuracy of the finish can be improved.

Although the invention has been described in relation to a specific embodiment of one method of the invention, it will become apparent to those skilled in the art that numerous

modifications and variations of th invention can be made within th scope and spirit of the invention as defined by the attached claims.

CLAIMS

1. In a method of manufacturing a valve seat-forming member of a fuel injection valve comprising a main fuel injection valve body; an electromagnetic coil in said valve body a fixed core in said valve body; a movable core attracted magnetically to said fixed core by said coil; a valve rod attached to said movable core and having an end with a valve body; and a valve seat-forming member attached to said valve body with said valve rod guidably received therein; the improvement comprising forming a bore in the valve seat-forming member of the fuel injection valve to serve as a guide for opening and closing displacement movements of said valve rod, forming a valve seat continuing from the guide bore for seating of said valve body, forming a fuel discharge port continuing from said valve seat burnishing at least one of said guide bore and said valve seat, and hardening said seat-forming member after said burnishing.

2. The method as claimed in claim 1 wherein the guide bore is formed by a drill rotating about an axis, said burnishing being effected by rotating a tool about the same axis as said drill.

3. The method as claimed in claim 2 wherein said tool has two burnishing surfaces for effecting burnishing of said bore and said seat.

4. The method as claimed in claim 3 wherein the bore and seat are burnished concurrently.

5. The method as claimed in claim 2 wherein said seat-forming member is held in a jig during formation of said bore, seat and port and the burnishing is effected with said seat-forming member held in said jig.

6. A method of manufacturing a valve seat-forming member of a fuel injection valve, substantially as hereinbefore described with reference to Figures 2, 3 and 4 of the accompanying drawings.

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